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An Inventory of the Herpetofauna of Ulu Baleh, the Remote Interior of Borneo

The mountainous terrain and fast-flowing rivers of Borneo have limited outside contact, especially for the island's central spine that separates the southeastern part (Indonesia's Kalimantan) from the northwestern parts (Malaysia's Sabah and Sarawak states). The area forms the catchment for the longest river on the island, the Rejang, which is fed by two main tributaries originating from these mountains. One of these is the Baleh, its upstream segment referred to as the Ulu Baleh. The region comprises a mountain chain as well as plateaus that reach about 300–1000 m elevation, underlain by volcanic rocks consisting predominantly of tuff and dactic rocks, with scattered agglomerate (Muol and Noweg 2018). Historically, the Ulu Baleh region has supported a relatively low human population, on account of the difficulty of access. Scientific exploration of the region began in the 1960s, with the arrival of the American herpetologist Robert Frederick Inger (1920–2019), who conducted long-term ecological and taxonomic studies on the frogs and reptiles of Mengiong and Nanga Tekalit (Das 2004), and published voluminous literature on the fauna (see, for instance, Inger et al. 2017). These, and the ichthyological surveys conducted at the time (reported by Parenti and Lim 2005) are restricted to the Lower Baleh region, with no information available from the more remote Upper Baleh. There appears to have been no other scientific expeditions to the area, the only available report dealing with the area being a popular account by O'Hanlon (1985), which provides a description of what the interior of Sarawak was like at the time.

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With industrialization and resource exploitation occurring across Sarawak, the once remote Ulu Baleh is now becoming more accessible. Driven by the logging industry, many large-scale timber extraction projects provide access to the area, not only by diesel-powered vessels via rivers, but also through land transportation, a feat once accomplished only on foot or via the Rejang River, using longboats. Access has dramatically altered the landscape of primary forests into a mixture of secondary forests, logged over forest patches, cleared land, plantations, and networks of logging roads. Apart from landscape change, it has also introduced new settlements of timber workers, adding to the population of native people. These threaten once pristine habitats.

There is relatively poor documentation on the herpetofauna of Borneo compared to other vertebrate taxa, hence the understanding of these groups remains inadequate. Records of amphibians and reptiles on Borneo, especially from the interior part of the island, are few. An important site for the logging

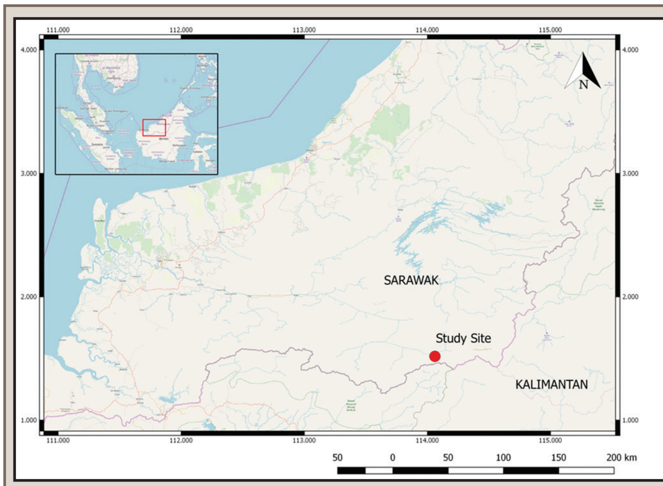

Fig. 1. Map of the expedition locality within the Baleh National Park, Sarawak. Resulting from the current expedition, the Park was gazetted on 21 September 2017, and covers an area of 66,721 ha^2. Inset: Map of Borneo, showing enlarged area of central and western Sarawak.

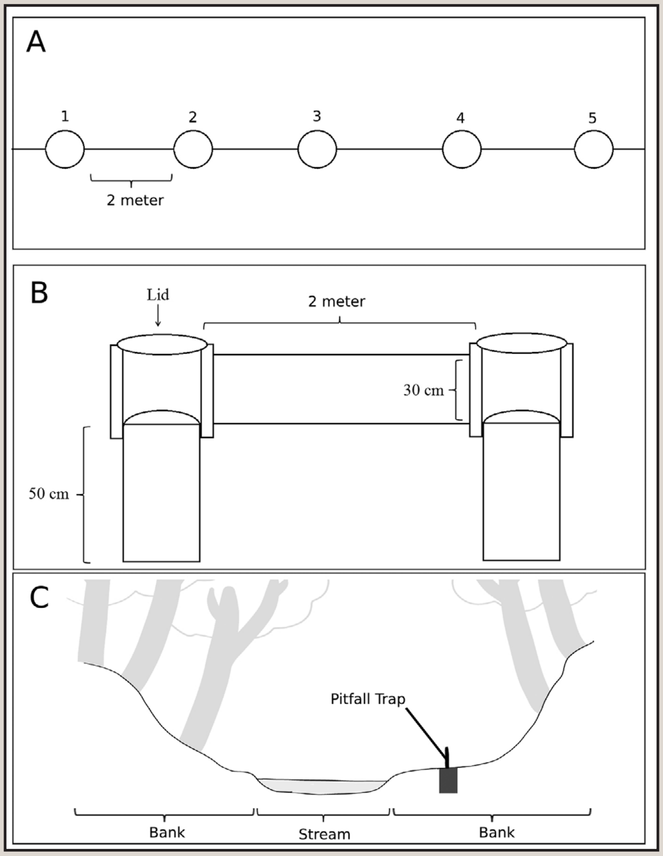

Fig. 2. Design for layout of pitfall trap array along transect within the study site in Baleh, Sarawak. (A) top view; (B) lateral view of the pitfall traps array.

Fig. 3. Image of pitfall traps within the study site at Baleh, in the interior of Sarawak State.

industry, the forested area of Borneo has been exploited since the 1970s for its valuable timber species. The current study was part of an expedition aimed at documenting the biodiversity and geology of the Ulu Baleh area, with the hope that information gathered will be useful for conservation and management planning, especially in the establishment of the Ulu Baleh National Park.

Methods

A one-week survey was conducted between 21–28 November 2015 in Ulu Baleh region, Kapit, Sarawak (01.55805°N; 114.18411°E; > 300 m above sea level) (Fig. 1). The area is under a logging concession owned by Elite Honour Camp of the WTK Group of Companies, where the company attempts to apply Sustainable Forest Management techniques to minimize impact on the environment. A combination of Visual Encounter Survey and Acoustic Encounter Survey techniques were employed to rapidly survey four 1000-m stream transects and one 500-m terrestrial transect in selected areas of the forest, involving a group of five field researchers. We selected sites based on factors such as history of logging at the site, accessibility, and presence of water bodies. Each of the transects were surveyed once, from 1900 to 0000 h, during which surveyors detected presence of animals based on eye shine and advertisement calls while walking at a slow pace, and carefully examining likely microhabitats with the aid of headlamps and flashlights. For unknown calls, we would look for the callers by having two or more surveyors actively search the area for about 10 minutes via triangulation.

An array of nine 50-cm-deep pitfall traps, each with a 1 m x 30 cm fence from each pitfall was established along a transect near the logging camp (01.55823°N, 114.18812°E) to optimize sampling intensity (Figs. 2, 3). The array was deployed along the stream bank, under canopy cover, with one of the array arms pointing towards the stream. The pitfalls were left open throughout the one-week sampling period, and were checked twice a day; once at approximately 1400 h and again after each of the transect visits during night time (0000–0100 h). In addition, we included opportunistic sightings. Voucher specimens were collected; these were fixed in 4% formalin before preservation in 70% ethanol. We also extracted liver tissues of these individuals and preserved them in absolute ethanol for future molecular studies. Specimens were deposited at the Systematics and Ecology Lab, Institute of Biodiversity and Environmental Conservation, Universiti Malaysia Sarawak. Nomenclature follows Haas et al. (2019) for amphibians and Uetz (2019) for reptiles.

Table 1. Herpetofaunal species recorded in the Ulu Baleh National Park. IUCN Status: NE – Not Evaluated, DD – Data Deficient, LC – Least Concern, NT – Near Threatened, VU – Vulnerable. Single asterisks (*) indicate species detected from pitfall trapping. Double asterisks (**) indicate species recorded from opportunistic sightings.

Taxon	Common Name	IUCN Status
Amphibians		
Bufonidae		
Ansonia longidigita Inger, 1960	Long-fingered Slender Toad	LC
Ansonia aff. *minuta* Inger, 1960	Dwarf Slender Toad	NT
Rentapia hosii (Boulenger, 1892)	Hose's Tree Toad	LC
Rentapia everetti (Boulenger, 1896)	Marbled Tree Toad	LC
Dicroglossidae		
Limnonectes cf. *kuhlii* (Tschudi, 1838)	Kuhl's Creek Frog	LC
Limnonectes leporinus (Andersson, 1923)	Giant Creek Frog	LC
Limnonectes ibanorum (Inger, 1964)	Rough-backed Creek Frog	LC
Microhylidae		
Chaperina fusca Mocquard, 1892	Saffron-bellied Frog	LC
Metaphrynella sundana (Peters, 1867)	Tree-hole Frog	LC
Microhyla petrigena Inger & Frogner, 1979	Pothole Narrow-mouthed Frog	LC
Megophryidae		
Megophrys edwardinae Inger, 1989	Edwardine's Horned Frog	LC
Megophrys nasuta Schlegel, 1858	Malayan Horned Frog	LC
Leptobrachella sp.	Litter Frog	–
Leptolalax sp.	Litter Frog	–
Ranidae		
Amnirana luctuosa (Peters, 1871)	Mahogany Frog	LC
Chalcorana raniceps (Peters, 1871)	White-lipped Frog	LC
Meristogenys phaeomerus (Inger & Gritis, 1983)	Kapit Torrent Frog	LC
Odorana hosii (Boulenger, 1891)	Poisonous Rock Frog	LC
Pulchrana picturata (Boulenger, 1920)	Spotted Stream Frog	LC
Staurois guttatus (Günther, 1858)	Black Spotted Rock Frog	LC
Staurois latopalmatus (Boulenger, 1887)	Rock-skipper Frog	LC
Staurois parvus Inger & Haile, 1959	Small Rock Frog	VU
Rhacophoridae		
Leptomantis harrissoni (Inger & Haile, 1959)	Harrisson's Tree Frog	LC
Leptomantis cyanopunctatus (Manthey & Steiof, 1998)	Blue-spotted Tree Frog	LC
Leptomantis gauni (Inger, 1966)	Short-nosed Tree Frog	LC
Philautus hosii (Boulenger, 1895)	Hose's Tree Frog	LC
Polypedates otilophus (Boulenger, 1893)	File-eared Tree Frog	LC
Rhacophorus pardalis Günther, 1858	Harlequin Tree Frog	LC
Ichthyopiidae		
Ichthyophis sp.	Striped Caecilian	–
Reptiles		
Agamidae		
Draco melanopogon Boulenger, 1887**	Black-bearded Gliding Lizard	NE
Draco quinquefasciatus Hardwicke & Gray, 1827**	Five-banded Gliding Lizard	NE
Gonocephalus grandis (Gray, 1845)	Great Angle-headed Lizard	LC
Phoxophrys nigrilabris (Peters, 1864)	Dark-lipped Shrub Lizard	LC
Colubridae		
Ahaetulla prasina (Boie, 1827)	Oriental Vine Snake	LC
Boiga cynodon (Boie, 1827)**	Dog-faced Cat Snake	LC
Pseudorabdion albonuchalis (Günther, 1896)	White-collare Reed Snake	LC
Eublepharidae		
Aeluroscalabotes felinus (Günther, 1864)	Bornean Cat Gecko	NE

Table 1. Continued.

Taxon	Common Name	IUCN Status
Gekkonidae		
Cyrtodactylus sp.	Bent-toed Gecko	–
Cyrtodactylus pubisulcus Inger, 1957	Inger's Bent-toed Gecko	NE
Gekko monarchus (Schlegel in: Duméril & Bibron, 1836)	Spotted Warty Gecko	LC
Scincidae		
Eutropis multifasciata (Kuhl, 1820)	Common Sun Skink	LC
Tropidophorus beccarii Peters, 1871	Beccari's Water Skink	LC
Tropidophorus micropus van Lidth de Jeude, 1905*	Small-footed Water Skink	NE
Tropidophorus sp.*	Baleh Water Skink	–
Tytthoscincus hallieri (van Lidth de Jeude, 1905)*	Hallier's Skink	NE
Pythonidae		
Malayopython reticulatus (Schneider, 1801)**	Reticulated Python	LC
Xenodermatidae		
Xenodermus javanicus Reinhardt, 1836	Rough-backed Litter Snake	LC
Trionychidae		
Dogania subplana Geoffroy Saint-Hilaire, 1809	Malayan Soft-shelled Turtle	LC

Results and Discussion

A total of 48 species of amphibian and reptile were recorded at Ulu Baleh, based on the sampling undertaken during the present expedition (Table 1). Some were considered as rare and uncommonly encountered, such as *Megophrys edwardinae, Tropidophorus micropus,* and *Xenodermus javanicus*. Species associated with anthropogenic disturbance were not recorded in the area. Large snakes, such as *Malayopython reticulatus* and *Boiga cynodon,* were found along the logging road, presumably on account of high visibility provided by cleared forests that allow higher encounter frequency. Not surprisingly, this survey also recorded species that do not match any description, suggesting that these might represent undescribed species. Systematic studies are currently ongoing to confirm the identity of these individuals.

The Visual Encounter Survey (VES) method relies on whether an animal is visible to the investigator during the survey. Our data suggest that ongoing logging activities in the area enhance the visibility of some species because concealing habitat cover is removed. Forest clearings for building of infrastructure, such as roads, houses, and timber collection sites allow animals to be sighted either at the edge of the forest or when they were moving between forest patches. Roadside pools were also utilized by species such as *Amnirana luctuosa* and *Chalcorana raniceps,* allowing high visibility at the forest edge. *Rentapia everetti* was found in abundance along newly logged sites, suggesting that habitat loss is a factor that contributed to higher encounter, as the species is known to be arboreal. Some animals were also affected indirectly by forest clearing. For instance, *Megophrys edwardinae* were found mostly perched on bare soil on stream banks in unlogged forests. Additionally, we recorded its calls from under thick leaf litter. A primary forest dweller, the coloration and unique body shape that mimics soil and leaf litter make them inconspicuous on bare soil and virtually undetectable in thick leaf litter. All of our records for this species were from bare soil, and although we heard multiple calls from within leaf litter, none were visually detected from that habitat. This suggests that even in an unlogged forest, habitat disturbance may occur due to soil erosion at stream banks, caused by increases in stream velocity. We did not find human commensal species, with the exception of *Gekko monarchus,* although logging activities here started nearly four decades ago. The remoteness of Ulu Baleh perhaps contributes to a lack of immigration of human commensals, and natural barriers, such as large rivers and high elevations help in controlling colonization by such non-native species.

Pitfall trapping is a passive method commonly used for amphibian and reptile surveys. It increases detection rate, especially for fossorial and leaf-litter dwelling animals, which were otherwise difficult to record using the VES method. We captured species of the scincid genera *Tropidophorus* and *Tytthoscincus* using pitfall trap arrays established near streams within primary forest. Species of *Tropidophorus* are usually found resting in between rocks near streams and quickly plunge into the current and hide under rocks when disturbed. Sampling of these animals by pitfall trapping demonstrated that the method is important to optimize detection in a rapid survey, albeit expensive in terms of labor and materials. However, we acknowledge that our pitfall system failed to capture frogs, possibly because they were not deep enough, or the fences established not suitably high to prevent the larger frogs from jumping out.

Our rapid survey found species that are uncommonly encountered elsewhere (Fig. 4), such as *Megophrys edwardinae, Rentapia everetti, Tytthoscincus hallieri,* and *Tropidophorus micropus,* all being Bornean endemics. In fact, the last-mentioned species was rediscovered after a hiatus of a century (Pui and Das 2017). We encountered *M. edwardinae* and *T. micropus* within primary forest patches, which were left unlogged to preserve headwaters of streams. We also found several frogs and reptiles that might represent undescribed species. These findings imply that primary forest patches are important as refuges for animals within a disturbed landscape. Undisturbed forests might contain more microhabitats that can be utilized by larger number of species, especially frogs and reptiles, as these groups show strong association with their respective habitats.

Fig. 4. Herpetological species from the Baleh National Park area recorded during the present field work. A) *Rentapia everetti*; B) *Megophrys edwardinae*; C) *Tropidophorus micropus;* and D) *Xenodermus javanicus*.

Consequently, their motility is limited compared to mammals and birds, and their populations are arguably more susceptible to extirpation via habitat fragmentation. In addition, preserving streams within these patches in the headwaters would help maintain corridors for movement. Headwaters of streams have previously been shown to be reservoirs of amphibian diversity as well as endemicity (Pui and Das 2016). Records of potential new species of frogs and reptiles within these patches suggest that even after a hundred years of scientific exploration, surveys are still necessary, especially within remote parts of Borneo. This is particularly critical given the ongoing rapid developments that threaten to reduce forested areas.

The Ulu Baleh region is home to significant herpetofaunal diversity, and is also important for several industries. Conservation management plans that address the need for preserving pockets of primary forests and streams are strongly recommended. Forest clearing generally enhances visual encounters of animals and improves access to remote sites, and as such, can have conservation impacts related to illegal collection of commercially valuable species. Herpetofaunal examples include the large species of *Limnonectes*, in addition to reptiles such as *Malayopython* and *Varanus*. Not surprisingly, our survey also recorded species that do not match any description (listed as unidentified species in Table 1), implying they could represent undescribed species. The detection of rarely encountered as well as possibly undescribed species indicates that rapid surveys of this nature are useful, particularly in poorly explored parts of Borneo, and have the potential to increase our understanding of the island's biodiversity.

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Identity, Habitat, and Relative Abundance of a Population of Teiid Lizards of the Genus *Cnemidophorus* in Caribbean Coastal Guna Yala Indigenous Region, Panama

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The traditional taxonomic treatment of the gonochoristic populations in the *Cnemidophorus lemniscatus* complex (Squamata: Teiidae) as representatives of a single species distributed in mainland Central America and certain Caribbean islands (sensu Burt 1931; Echternacht 1968; Montgomery et al. 2007, 2011) has obscured the existence of several distinct species (McCranie and Hedges 2013). Using limited genetic, and mostly morphological criteria, McCranie and Hedges (2013) allocated specimens in the complex from Belize (apparently introduced), Guatemala, Honduras and certain of its islands (e.g., Cayo Cochino Pequeño, Roatán, and Útila), and extreme northeastern Nicaragua to *C. ruatanus* (name resurrected from synonymy in a new combination), those from Darién Province, Panama, to *C. duellmani* (newly described), and those from the Colombian islands Providencia and San Andrés in the Caribbean Sea to *C. espeuti* (name resurrected from synonymy in the original combination). Prior to the report of McCranie and Hedges (2013), JMW had examined mainland and insular samples of lizards from Guatemala, Honduras, and Panama and found no instances of sympatry between populations, which they subsequently described as the allopatric species *C. ruatanus* and *C. duellmani*. All specimens examined from several museum collections generally conformed to critical parts of the diagnoses of either *C. ruatanus* (eight rows of ventral scales and a distinct longitudinal stripe configuration in the vertebral field) or *C. duellmani* (10 rows of ventral scales and presence of a hazy longitudinal configuration in the vertebral field of adults).

In 2005, CEM visited Guna Yala indigenous region, formerly Kuna Yala and San Blas, a narrow northern zone in Panama, bordered to the north by the Caribbean Sea and to the south in part by Darién Province. Unexpectedly, he observed a previously unreported species of the *C. lemniscatus* complex in Guna Yala (see McCranie and Hedges 2013; fig. 7). This report was prepared to document the presence of the Panamanian coastal Caribbean population of lizards in the *C. lemniscatus* complex, to identify it to species, describe its habitat preferences, and comment on its relative abundance.

Materials and Methods

Field observations, notes on two live individuals, and three photographs representative of the newly discovered population of *Cnemidophorus* discussed herein were obtained by CEM during a visit to Guna Yala (Fig. 1) along the Caribbean coast in northeastern Panama on 12 November 2005. Although he did not have a permit to retain voucher specimens, photographs of a lizard in-situ (Fig. 2A) and of two captured and released males (Fig. 2B–C) provided the first documentation of the presence of cnemidophorine lizards in Caribbean coastal Panama (see McCranie and Hedges 2013; fig. 7). The live individuals were captured by hand in 2005 with the assistance of local youths. Whiptail lizards in abundance, including numerous large adults, were active from mid-morning throughout the afternoon on the date of the visit. Plans to return to Guna Yala have not materialized, hence the delayed preparation of this report.